

L Number	Hits	Search Text	DB	Time stamp
1	803678	oblique or angle or angled	USPAT; US-PGPUB	2002/08/06 18:51
2	100666	implant or implantation or implanted or implants	USPAT; US-PGPUB	2002/08/06 18:51
3	3949	(oblique or angle or angled) with (implant or implantation or implanted or implants)	USPAT; US-PGPUB	2002/08/06 18:52
4	60	438/447.ccls.	USPAT; US-PGPUB	2002/08/06 18:52
5	5	((oblique or angle or angled) with (implant or implantation or implanted or implants)) and 438/447.ccls.	USPAT; US-PGPUB	2002/08/06 18:55
6	8080	locos	USPAT; US-PGPUB	2002/08/06 18:56
7	37	((oblique or angle or angled) with (implant or implantation or implanted or implants)) same locos	USPAT; US-PGPUB	2002/08/06 19:11
8	168	(438/525).CCLS.	USPAT; US-PGPUB	2002/08/06 19:11
9	32	locos and ((438/525).CCLS.)	USPAT; US-PGPUB	2002/08/06 19:11
10	28	(locos and ((438/525).CCLS.)) not (((oblique or angle or angled) with (implant or implantation or implanted or implants)) same locos)	USPAT; US-PGPUB	2002/08/06 19:28
11	271361	trench or recess	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:29
12	792879	oblique or angle or angled	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:29
13	94552	implant or implanted or implantation or implants	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:29
14	250	(trench or recess) and (oblique or angle or angled) and (implant or implanted or implantation or implants)	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:30
15	176746	locos or oxidation	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:30
16	16	((trench or recess) and (oblique or angle or angled) and (implant or implanted or implantation or implants)) and (locos or oxidation)	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:30

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DISCLOSURE TEXT:

3p. An improved process which minimizes the width of the recessed oxide (ROX) region, thereby providing higher packing density of active devices, and which minimizes the spread of additional boron at the sides of the ROX region, thereby separating the boron channel stopper from the implanted or diffused regions of

active devices at

the silicon surface, is described. Minimizing the spread of the

boron channel stopper, leads to better electrical isolation of active

devices and reduced leakage from device to substrate for p-type silicon substrates.

- In a known process, an anisotropic etch was used to define a

steep walled and flat bottomed hole or recess in (110) or (100)

silicon. Subsequently, a thermal oxide (ROX) was grown in the recess.

The advantage of the anisotropic etch over an isotropic etch is that

the width of the ROX region is less, allowing higher packing density

of active devices at the silicon surface. For p-type silicon

substrates, boron was ion implanted after etching the recess to

compensate for boron depletion which occurs during growth of the thermal oxide.

- Using this prior art process, an SiO(2) layer approximately

4000 Angstroms thick was used as the implantation mask. A major

problem associated with this thick SiO(2) implantation mask is that

even though a very steep walled hole or recess

can be opened in the resist using electron-beam techniques, excessive undercutting of the SiO(2) mask occurs during etching. The lateral undercutting is approximately equal to the SiO(2) thickness.

- Furthermore, since the SiO(2) walls are sloped at an angle of approximately 45 degrees, the implantation masking capability is not 100% at the edges of the mask. This can produce an undesirably high-boron concentration on the side walls of the ROX region at the silicon surface. As a result, implanted or diffused source and drain regions of active devices immediately adjacent to the ROX region may exhibit reduced breakdown and/or excessive junction leakage.
- If a photoresist layer is used as an ion implantation mask, rather than a thick SiO(2) layer, then a much thinner SiO(2) layer (e.g., less than 500 Angstroms) can be used, thereby relieving the SiO(2) undercutting problem discussed above. Fig. 1 shows a photoresist mask 1 having a thickness of 5000 Angstroms deposited on a layer 2 of SiO(2) having a thickness of 500 Angstroms and a layer 3

of Si(3)N(4) having a thickness of 500 Angstroms on a silicon

substrate 4. The eventual mask opening 5 at the silicon surface will

be 5000 Angstroms plus 500 Angstroms (for the SiO(2) mask) plus 500

Angstroms (for the Si(3)N(4)), or 6000 Angstroms total. Then the

width of the ROX region will be 6000 Angstroms plus 80% x 4000

Angstroms (for the ROX undergrowth) or 9200 Angstroms total.

- If an SiO(2) mask of 4000 Angstrom thickness is used, the mask

opening at the silicon surface would be 5000 Angstroms plus 4000

Angstroms plus 500 Angstroms or 9500 Angstrom total, and the eventual

Width of the ROX region would be 9500 Angstroms plus 80% x 4000

Angstroms, or 12,700 Angstroms total. In Fig. 1, the SiO(2) is

removed using well-known photolithographic masking and etching techniques.

- For p-type substrates, boron (as indicated by arrows 6 in Fig.

2) will be ion implanted into the silicon 4 through the Si(3)N(4)

layer 3, forming an implanted region 7 in the silicon 4. It should

be noted that boron is implanted prior to etching

either the

Si(3)N(4) layer 3 or the silicon 4, because etchants for these

materials attack the resist layer 1. The portion of the SiO(2) layer

2 to be removed in opening 5 can be removed either before or after

the boron implantation, as desired. Both layers 2 and 3 are

necessary in the process; the SiO(2) layer 2 to define a hole in

Si(3)N(4) layer 3, and the Si(3)N(4) layer 3 to prevent ROX growth over

selected areas of the surface of silicon wafer 4.

- Fig. 3 shows the structure after removal of that portion of the

Si(3)N(4) layer 3 over implanted region 7, using layer 2 as an etching

mask. Si(3)N(4) can be removed using well-known etches such as

H(3)PO(4). Fig. 4 shows the result of a subsequent step in which an

anisotropic etch such as KOH is utilized to form a 2000 Angstroms

deep recess 8 in silicon 4 using layer 3 as an etching mask. Note

that a portion of the boron implanted region 7 is also removed.

Next, the remaining portions of the SiO(2) layer 2 are removed by

conventional etches. Finally, ROX region 10 is formed by thermal

oxidation of silicon 4 as shown in Fig. 5.

- Annealing and diffusion of the implanted boron occurs during the high-temperature growth of ROX region 10, which is accomplished by a dry-wet-dry thermal oxidation at 1000 degrees C for approximately 90 minutes. During this thermal cycle, the boron implanted region 7 outdiffuses leaving a doping greater than $5 \times 10^{16}/\text{cm}^2$ at the Si-SiO(2) interface, as shown in Fig. 5. The boron implantation parameters are: dose $5 \times 10^{12}/\text{cm}^2$, energy 100 KeV, range 3000 Angstroms, and standard deviation 600 Angstroms. Under these conditions, the resist layer 1 is not expected to polymerize and can still be easily removed with conventional etches.

- The above process offers the following advantages:

1. Instead of using a thick SiO(2) layer for both Si(3)N(4) delineation and boron implantation masking, a thin SiO(2) layer is used for Si(3)N(4) delineation and a resist layer with vertical walls is used for implantation masking. This results in a reduction of the width of ROX region 10 from 12700 Angstroms to

9200 Angstroms for
comparable processes.

- 2. The resist layer can be made quite thick
(e.g., 5000

Angstroms), thus giving a high degree of implant
masking.

- 3. The walls of the resist layer can be
made much steeper than

the walls of an etched SiO₂ layer, thereby
giving a very steep

walled implant region 7. The ROX region 10
extends beyond the

implanted boron region 7 near the silicon surface,
leaving a p-type

channel stopper 9 beneath the ROX region 10 and
on the ROX sidewalls

but well separated from the surface of the silicon,
as shown in Fig.

5.

- 4. The same resist mask may be utilized in
situations where

another ionic species is used, to help define the
depth and flatness

of recess 8 prior to etching of silicon 4.

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